We thank all three referees for assessing the manuscript and the constructive and thought-provoking suggestions. We have considered needed and valuable suggestions, and explain in this letter where we have implemented changes along with the reason. Please find below the comments and the corresponding replies.

Referee 1

Comment 1.1) This is a laudable article providing new and important background on the geomorphology and environmental conditions that lead to the damages. It is very informative, well written and helpful to national and international scientists. The style is rather descriptive and narrative, but common in certain fields of geomorphology and geography. Maybe a methodology section could help others to understand, how the data and information was retrieved; when, where, by whom etc. As another positive aspect, the text is quite easy to understand for non-specialists, too. Very informative analysis using aerial imagery of the gravel pit in Blessem, too.

Reply 1.1) We appreciate the assessment of the style of the manuscript. Indeed, our implicit aim was to provide a rather descriptive document on the non-hydraulic elements of the flood and make it accessible and exciting especially for non-specialists. Thus, we decisively steered against a heavily data-laden and intense analytical approach. We have added a methods section to allow readers to comprehend better and reproduce the results presented. In this section, we also explicitly explain the narrative and descriptive pitch of the manuscript.

Comment 1.2) Line 17 and other areas (not just the Ahr)

Reply 1.2) We have corrected/generalised/clarified wherever appropriate.

Comment 1.3) Line 18: is it a hazard or rather already a "hazard event" or "process"?

Reply 1.3) Changed to "hazard event"

Comment 1.4) Line 56 explain a bit more, what "is difficult to manage"

Reply 1.4) We removed the equivocal and unnecessary phrase.

Comment 1.4) Line 78 large parts of text seem to be based on the author's field observations and expert experience and knowledge, it seems. It would be helpful for readers to make this more explicit in some sections, such as 78 - 86. Maybe add something such as "we have witnessed at field observations in the Ahr area after the floods" or similar. Some claims without sources are a bit risky, as in Line 86.

Reply 1.4) In the specific case, additional references were added, and the text was clarified to indicate what our assessments are based on and where we suggest rather than deduce. Also, in other cases, we have revised the text to improve the notion of mapping-based implications.

Comment 1.5) Following text: the style is quite descriptive and narrative, as it is common in geomorphology, so I do not criticise it. But at certain claims, some more support could be added,

when available. For instance, line 141-142, could you add some more detail such as (oral. com with affected citizens in VILLAGE, DATE...)?

Reply 1.5) We have revised the text to either remove unsupported claims or provide an adequate supporting reference. However, after asking the eye witness, we would be hesitant to reveal the name and position of the contact for privacy reasons, noting that such indications are overall rare cases and if the are used they refer to scientific contact persons rather than inevitably exposed non-scientific people. In any way, if the editor insists on that point, we would revise the text and remove that discussion part. Apart from that one point, the following occasions are now with by additional information (line numbers referring to the initial manuscript version):

- l. 84, increased flashiness through gullying, reference added
- l. 89-92, debris flows contributing woody debris, reference added
- l. 96, the impact of debris flows on river profile and hydraulic geometry, reference added
- l. 97, clarified that we mapped debris flow source points
- l. 126, overland flow depths needed to entrain logs, reference added
- l. 136, effects of large woody debris-flow, reference added
- l. 145, log jam effects in the main valley referenced
- l. 158, bedrock erosion, clarified that result is based on own mappings
- l. 194, inundation depths, reference added
- l. 236, shear stress, reference added
- l. 256, dam morphology numbers, method added

Referee 2

Comment 2.1) This is an important, though preliminary, assessment of the non-hydrologic, “landscape”, aspects of the July 2015 extreme precipitation event in the Ahrtal and Rhein-Erft region in Germany. The work provides an important complement to purely meteorological and hydrological studies. The investigation is preliminary in the sense that it based on exemplary observations and does not attempt a full systematic recording of landscape effects, but rather tries to identify and describe a few “typical” examples illustrating a couple of process features. In this spirit the publication provides a valuable entry point for more systematic investigations and is certainly a valuable contribution worth publishing.

Reply 2.1) We appreciate the assessment of the style of the manuscript. As pointed out in our response to referee 1 (reply 1.1), we decisively structured and designed the text that way, a point which is now explicitly mentioned at the start of the added methods section.

Comment 2.2) However, the authors, even in their preliminary approach, might provide some thoughts and further information on at lost two respects: Lines 286-289: “To overcome this systematic shortcoming, other systems need to be implemented, systems that are able to collect distributed multivariate data at high temporal resolution and that are not endangered by hostile flood conditions. Instead of just the main channel, such high quality flood related process information should also be available for headwater regions, where the 2021 flood gained its momentum and non-linearity.” – While this is without doubt a valid conclusion, the authors should offer at least some preliminary ideas on if and how they believe this could be achieved in terms of feasible methodological and technical approaches. What system might be envisaged? What type of parameters might be recorded? Where do we have technical/organizational solutions? How might these be integrated into next generation models and risk management? – Not a systematic exploration (which would be beyond the scope of the paper), but a couple of ideas.

Reply 2.2) Indeed, this is correct. We have added a short description of and reference to one such possible approach.

Comment 2.3) 2. Line 195: In terms of past events the authors just mention the 2006 and 2013 events, whose intensities have considerably below the 2021 event. The authors should at least give a reason why they don´t make use the information on the larger events in the Ahrtal in 2010 and particularly 1804 which have been closer to 2021 with respect to intensity, and for which there is quite some documentation. The question on if and how to use, or not to use, this type of historical information (even if the corresponding report of course don´t reach today´s standards and the environmental and infrastructural was different), should be discussed at least shortly.

Reply 2.3) This is a valid and essential point. We have now addressed why we did (and do) not include the 1804 event in our discussion. The main point is the different land-use and settlement arrangements in the Ahr valley some 220 years ago. As for the 2010 event, there were simply no investigations performed by the group used in the reference. Hence, we acknowledge the critical referee note and explain the inclusion and exclusion of the respective events.

Comment 2.4) In addition, a detail comments concerns statement in lines 18-20. I wonder if nothing beyond “media report” can be cited with respect e.g. to the statement that “hydraulic models

underpredicted the actual flood wave...". The authors might try to list some more solid references for this important statement than just media reports.

Reply 2.4) We clarified that sentence. Our reference to media reports was not concerning hydraulic models or mitigation efforts but just on the media attention that was given to the flood evolution itself.

Referee 3

Comment 3.1) The manuscript focuses on the “boundary conditions” that lead to damages in the July 2021 flood in the Eifel region. The paper is very interesting, well written and well organized. I have just a minor comment. In my opinion, in order to better appreciate the figures, in figure 1 the hillshade and slope map must be divided from the 3-day precipitation map, the intensity-duration-frequency curve must stand alone in a single figure and, in the figures 2 and 4, it is necessary to add a map with the locations of the pictures with star signatures that must be deleted from figure 1. For these reasons I suggest to modify the figures as follows:

Reply 3.1) We have replaced the slope map with just the hillshade map to avoid thematic content overlap. However, separating it from the precipitation map would decorrelate the spatial coherence we want actually to show. We have now separated Fig.1 a and b. Note the respective changes to the labels of all other figures. We do not see the benefit in removing the location indicators of the depicted focus sites for two reasons: first, the pictures in old figures 2,3,4 and 5 do in principal stand-alone without spatial reference needed because they illustrate representative process impacts across the affected wider region. Second, old Fig. 1a would lose substantially in map content if it would just show the two river systems and their topographic impression within a sub-region of Germany. We used that map to plot the star symbols as cross-link to the other figures. Hence, if possible, we would prefer to keep the content (apart from the slope map) of the original Fig. 1a.

Comment 3.2) Figure 1. Case study and meteorological measurements. a) two of the most affected river systems, Erft and Ahr (line width indicating stream order), on top of a hillshade and slope map (red colours). Inset shows the location of the map within Germany. b) 3-day precipitation accumulated for 12–15 July 2021 from RADOLAN data (CDC, 2022).

Reply 3.2) As expressed above, the spatial distribution of precipitation needs to be linked to the topography and, more essentially to the river systems conveying the resulting discharge. Thus, we simplified the map in old Fig. 1a by removing the explicit slope information and show old Fig. 1b now as a separate figure, as suggested in the comments above and below.

Comment 3.3) Figure 2. Intensity-duration-frequency (IDF) curve for the weather station Weilerswist-Lommersum. Observations of 14 July precipitation are added in black based on different measurement intervals. Coloured lines depict different non-exceedance probabilities, respective shadings indicate 90 % confidence intervals.

Reply 3.3) Done as suggested.

Comment 3.4) Figure 3. Landscape features emerging from the flood. a) Locations of the pictures with star signatures. b) Focussed discharge along the hillslope causing deep and fast flow and thus efficient drainage in the background. However, the provided water is not routed downslope in the foreground but ponded by infrastructure, and released at selected spots with increased erosive stream power. c) Deposition area of the debris flow shown in (d), injecting massive debris into the main channel (Trierbach), temporally blocking the stream and causing severe reorganisation of the hydraulic geometry. d) Lateral deposits of the debris flow at the end of the valley confined section.

Inset shows upstream knickpoint formed by overspill and erosion of clogged drainage pipe (50 cm diameter). e) Old slope instability (yellow line) above a 20 m high engineered terrace with industrial infrastructure on it. The terrace just east of the town of Antweiler had been undercut by the Ahr river during the flood.

Reply 3.4) The point with adding a map of the broader area to figures 2–5 is that it adds much redundant information, hence cutting off space for text and graphical information. As explained in reply 3.1, we propose that each of the figure panels (2–5) in principle holds, even without a direct link to the location within the Eifel area, because it depicts the process impacts of the flood event. We thus prefer to remain with the initial figure constellation.

Comment 3.5) Figure 4. Debris mobilisation features, Ahr valley near Müsch (cf. Fig. 1a) Aerial image (BBK-DLR, 2022) taken one day after the flood. The light green outline depicts the tree limit before the flood. Blues lines illustrate the pre-flood course of the Ahr river. b) View from the green star in (a) towards the eroded right bank, which had activated a 16 m high rockslide (persons for scale). Note flood impact mark on a remaining tree at 5 m above current water level.

Reply 3.5) Done as suggested.

Comment 3.6) Figure 5. Effects of large woody debris. a) Locations of the pictures with star signatures. b) Pair of clogged bridges near Altenahr, bypassed along the left and right bank. Note the bipartition of the collected debris with woody material caught by the downstream road bridge and anthropogenic debris collected later by the upstream railway bridge. Note two remaining standing trees in the river depicting the width of the Ahr river before the flood. Aerial image by (BBK-DLR, 2022). c) Huhnenbach near Aremberg about 2 km from its source (see Fig. 1). Note clogging by woody debris at riparian trees and the resulting ejection of coarse bed material out of the channel. d) Another clogging of the Huhnenbach some 20 m upstream of (c), with both ejected coarse debris and deposition of fine sediments in front of the obstacle.

Reply 3.6) See replies 3.4 and 3.1.

Comment 3.7) Figure 6. Aerial image (BBK-DLR, 2022) of the town of Blessem. a) Situation shortly after the flood event, with annotated features. The top right inset (b) shows conditions before the flood. The break in slope along the margin of a gravel pit (red dashed line) had started to erode towards the town by fluvial erosion (yellow line) that formed three individual clusters. The erosion was fuelled by overbank discharge of the Erft river, evading the town of Blessem and moving down the main street as well water flowing over the field west of the town margin, following the line of steepest descent. Water flow directions are indicated by blue arrows where visible from aerial imagery. The four numbered blue triangles depict sites of increased water input towards the pit.

Reply 3.7) Done as suggested.